

MODULE 4

BIODIVERSITY AND ECOSYSTEM

Biodiversity is defined as "**the variety and variability among all groups of living organisms and the ecosystems in which they occur.**"

Biodiversity is the abbreviated word for "**biological diversity**" (bio - life or living organisms, diversity-variety). Thus, biodiversity is the total variety of life on our planet, the total number of races, varieties and species. The sum of total of various types of microbes, plants and animals (producers, consumers and decomposers) in a system.



Biomes can be considered life zones, environment with similar climatic, topographic and soil conditions and roughly comparable biological communities (Eg. Grassland, forest). The biomes shelter an astounding variety of living organisms (from driest desert to dripping rainforest, from highest mountain to deepest ocean trenches, life occurs in a marvelous spectrum of size, shape, colour and inter relationship). The variety of living organisms, the biodiversity, makes the world beautiful. There are 1.4 million species known presently. But based on new discoveries, by research expeditions, mainly in tropics, taxonomists estimate there are between 350 million different species may be alive today. Insects make up more than one half of all known species and may comprise more than 90% of all species on earth

From the driest deserts to the dense tropical rainforests and from the high snow-clad mountain peaks to the deepest of ocean trenches, life occurs in a marvellous spectrum of forms, size, colour and shape, each with unique ecological inter-relationships. Just imagine how monotonous and dull the world would have been had there been only a few species of living organisms that could be counted on fingertips!

In the Convention of Biological diversity (1992) biodiversity has been defined as the variability

among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part.

When we observe our surroundings, we find different types of plants, ranging from small green grasses to large trees, large variety of animals, from tiny insects to human beings and many other big animals. Besides these there are micro-organisms in the soil, air and water that we can't see through our naked eyes. These varieties of plants, animals and microbes together form the biological diversity or biodiversity of your surroundings. So biodiversity can be defined **as the flora and fauna i.e. variety of all plants, animals and microbes of a region.**

Levels of Biodiversity

Biodiversity is classified into three types:

1. Genetic diversity
2. Species diversity and
3. Ecosystem diversity

GENETIC DIVERSITY: It is the basic source of biodiversity. The genes found in organisms can form enormous number of combinations each of which gives rise to some variability. Genes are the basic units of hereditary information transmitted from one generation to other. When the genes within the same species show different versions due to new combinations, it is called genetic variability. **For example**, all rice varieties belong to the species *Oryza sativa*, but there are thousands of wild and cultivated varieties of rice which show variations at the genetic level and differ in their color, size, shape, aroma and nutrient content of the grain. This is the genetic diversity of rice.

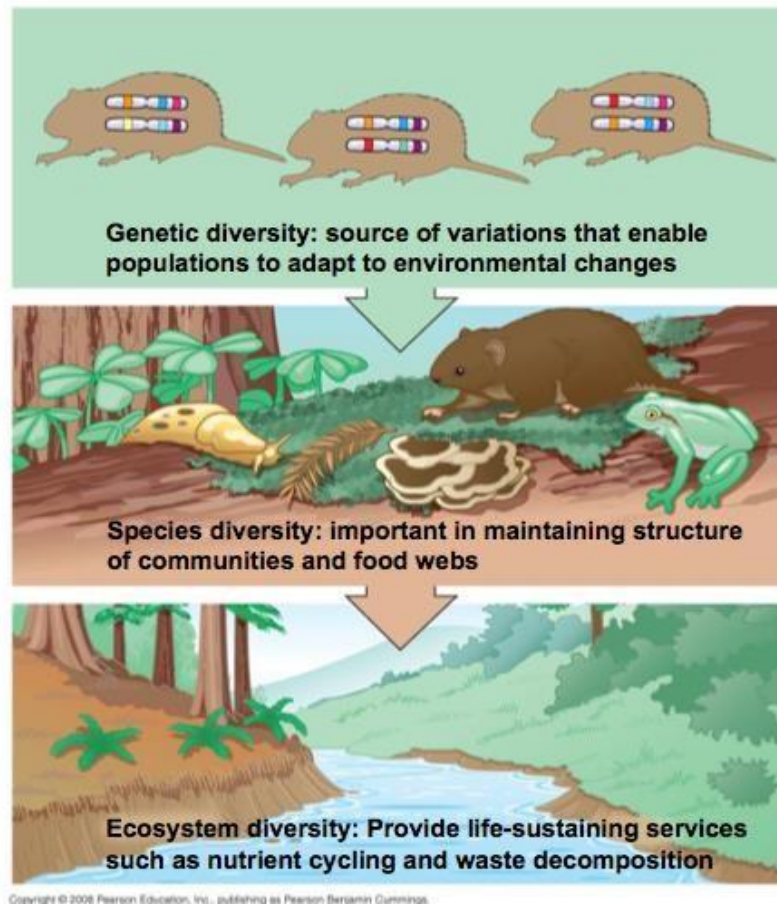
SPECIES DIVERSITY: This is the variability found within the population of a species or between different species of a community. It represents broadly the species richness and their abundance in a community. There are two popular indices of measuring species diversity known as Shannon-Wiener index and Simpson index.

What is the number of species on this biosphere?

The estimates of actual number vary widely due to incomplete and indirect data. The current estimates given by Wilson in 1992 put the total number of living species in a range of 10 million to 50 million. Till now only about 1.5 million living and 300,000 fossil species have been actually described and given scientific names. It is quite likely that a large fraction of these

species may become extinct even before they are discovered and enlisted.

ECOSYSTEM DIVERSITY: This is the diversity of ecological complexity showing variations in ecological niches, trophic structure, food-webs, nutrient cycling etc. The ecosystems also show variations with respect to physical parameters like moisture, temperature, altitude, precipitation etc. Thus, there occurs tremendous diversity within the ecosystems, along these gradients. We may consider diversity in forest ecosystem, which is supposed to have mainly a dominance of trees. But, while considering a tropical rainforest, a tropical deciduous forest, a temperate deciduous forest and a boreal forest, the variations observed are just too many and they are mainly due to variations in the above-mentioned physical factors. The ecosystem diversity is of great value that must be kept intact. This diversity has developed over millions of years of evolution. If we destroy this diversity, it would disrupt the ecological balance. We cannot even replace the diversity of one ecosystem by that of another. Coniferous trees of boreal forests cannot take up the function of the trees of tropical deciduous forest lands and vice versa, because ecosystem diversity has evolved with respect to the prevailing environmental conditions with well-regulated ecological balance.



IMPORTANCE OF BIODIVERSITY:

Biodiversity is essential for maintenance of ecosystem. It maintains gaseous composition of atmosphere, controls climate, helps in natural pest control, pollination of plants by insects and birds, soil formation and conservation, water purification Health and conservation, geo-chemical cycles etc

Some of the uses of biodiversity are given below:

- i) **Food:** All kind of food is derived from plants and animals.
- ii) **Drugs and Medicines:** Around 25% of drugs are obtained from plants e.g. quinin used for treatment of malaria is obtained from *Cinchona officinalis*. All antibiotics are derived from microbes.
- iii) **Cultural and Aesthetic value:** You enjoy watching butterflies, animals, birds and flowers. Eco-tourism is a source of income.
- iv) **Religious values:** Plants like tulsi, peepal, banyan and animals like cows, ox, elephant are

worshiped.

- v) Biodiversity conservation is essential for maintenance of ecosystem.
- vi) It is also required for disposal and pollination in plants, formation and conservation of soil and purification and conservation of water.

HOT SPOTS OF BIODIVERSITY:

Biodiversity is not uniformly distributed across the geographical regions of the earth. Certain regions of the world are very rich in biodiversity. We call such areas as “mega diversity zones”. We also refer to them as “hot-spots”. For example, India accounts for only 2.4 % of the land area of the world; but it contributes approximately 8% species to the global diversity due to existence of such pockets. The hot spots are the richest and the most threatened reservoirs of biodiversity on the earth.

The criteria for determining an area as a hot spot are:

- (i) The area should support >1500 endemic species,
- (ii) It must have lost over 70 % of the original habitat.

Twenty-five biodiversity hot spots have been identified in the world. These hot spots are characterized by supporting exceptionally high biodiversity. Among the 25 hot spots of the world, two are found in India namely Western Ghats and the Eastern Himalayas. These two areas of the country are exceptionally rich in flowering plants, reptiles, amphibians, butterflies and some species of mammals. The eastern Himalayan hot spot extends to the north – eastern India and Bhutan. The temperate forests are found at an altitude of 1780 to 3500 m. Many deep and semi-isolated valleys are exceptionally rich in endemic plant species.

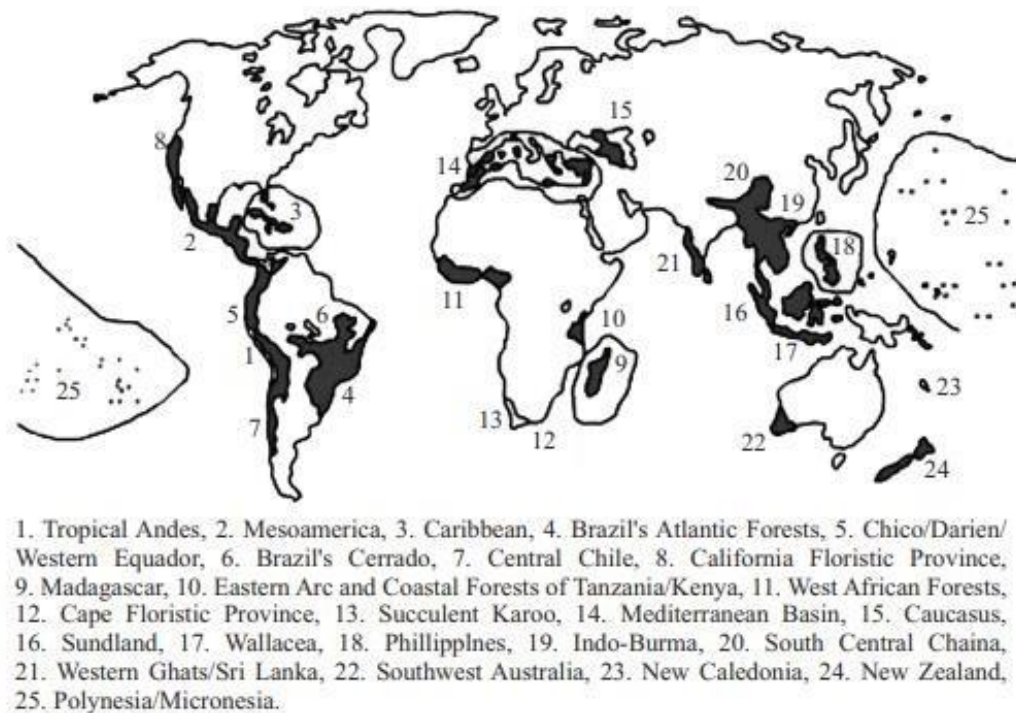


Fig. The terrestrial biodiversity hot spots

Hot Spots in India

In India we have 3 biodiversity hot spots

Western Ghats:

- Western Ghats region is spread over 6 states of India, they receive high rain fall.
- This region shows high species diversity and high levels of endemism.
- Nearly 77% of amphibians and 62% of the reptile species found here are endemic.
- The highest concentration of species in Western Ghats is believed to be in Agasthyamalai hills in extreme south.
- Western Ghats faced with tremendous population pressure; forests of the Western Ghats have been dramatically impacted demands for timber and agricultural land.
- At least 325 globally threatened species occur in Western Ghats.

It was found that loss of biodiversity in Western Ghats is about 2.4% per year.

Eastern Himalayas:

- The Himalayan hot spot is home to the world's highest mountains including Mount Everest.
- This region is geologically young and shows high altitudinal variation.
- World's major river systems arise in Himalayas and their combined drainage basin is home for 3 billion people in 18 countries.
- Eastern Himalayan hot spot has nearly 163 globally threatened species including Rhinoceros, Wild Asian Water buffalo and in all 47 mammals, 50 birds, 17 reptiles, 12 amphibians, 36 plant species.
- There are 10,000 species of plants in Himalayas of which 1/3rd are endemic and found nowhere else.

Indo-Burma Hot Spot:

- Indo-Burma region is spread out from Eastern Bangladesh to Malaysia including north-eastern states and is spread over 2 million sq.km of tropical Asia.
- Most of this region is still a wilderness, but has been deteriorating rapidly in the past few decades.
- In recent times six species of large mammals have been discovered here. This region is home to several species such as monkeys, langurs and gibbons.
- Almost 1300 bird species and 13,500 plant species are existing in this region and half of them are endemic.

INDIA AS A MEGA BIODIVERSITY NATION:

India is one of the 17 mega-diverse nations, is one of the richest nations in terms of biological diversity.

- India contains about 8% of the world's biodiversity.
- India is home to about 5 world heritage sites.
- India Ranks 10th among the plant richness countries.
- Indian ranks 6th among centre of biodiversity and origin of agricultural crops.
- With only 2.4% of world's land area, accounts for 8% of the species of the world. About 47,000 plant species and 81,000 animal species of India are endemic which are 7% and 6.5% of global diversity respectively.
- A large number of species which are originated in India are called as centre of origin

- Nearly 5000 species of flowering plants, 160 species of crops and 320 species of wild relatives of cultivable crops having centre of Origin in India
- India having about 7500 KM long coastal line
- It majorly contains Mangroves, Estuaries and Back waters where 340 species of corals of the world are found
- A large portion of Indian Biodiversity is still unexplored
- Due to very diverse climatic conditions there is a major diversity of species exists in our country.

Significance of Biodiversity: Biosphere is a life supporting system to the human race. Each species in the biosphere has its own significance. It is the combination of different organisms that enables the biosphere to sustain human race. Biodiversity is vital for a healthy biosphere. Biodiversity is must for the stability and proper functioning of the biosphere. Besides this biodiversity is so important due to having consumptive use values, productive use values, social values, ethical values and aesthetic values.

Benefits of biodiversity: We benefit from other organism in many ways. Even in significant organisms can play irreplaceable roles in ecological systems or the source of genes or drugs that some day become indispensable.

i) Food: Many wild plant species could make important contributions to human food suppliers either as they are or as a source of material to improve domestic crops. About 80,000 edible plants could be used by human.

ii) Drugs and medicine: Living organisms provides many useful drugs and medicines. The United Nations Development Programme derived from developing world plants, animals and microbes to be more than \$30 billion per year.

Eg. For natural medicinal products Penicillin – fungus is the source – Antibiotic Quinine – chincona bark - Malaria treatment Morphine – poppy bark – Analgesic.

Twenty years before, once the drugs were not introduced, childhood leukemia was fatal. Now the remission rate for childhood leukemia is 99%.

VALUES OF BIODIVERSITY

Definition and estimation of the value of biodiversity is not easy. Biodiversity provides a variety of environmental services from its species and ecosystems that are essential at global, local and regional levels. Loss of biodiversity contributes to climate change. Forests converts carbon

dioxide into carbon and oxygen. Loss of forests cover due to release of carbon dioxide and other gases due to industrialization which contributes to 'Green house effect. Green house leads to global warming which results in raise in sea-level submerging the low lying areas in the world and causing atmospheric changes.

The value of biodiversity is classified into:

1. **Direct Value and**
2. **Indirect Value**

Direct value of biodiversity is of two types,

1. Consumptive use value and
2. Productive use value

Consumptive use value: The consumptive use value is the value placed on nature's products that are consumed directly, without passing through a market.

Food: Plants: Most fundamental value of biological resources particularly plants is providing food. i.e., Wheat, Maize and rice constitute $2/3^{\text{rd}}$ of food requirement all over the world.

Fish: Through the development of aquaculture, techniques, fish and fish products have become the largest source of protein in the world

Fuel: Since ages forests have provided wood as fuel. Fossil fuels like coal, petroleum, natural gases are also product of biodiversity.

Drugs and Medicines: Traditional medicinal practices such as ayurveda utilize plants or their extracts directly. Many drugs were derived from plants

Quinine: Famous anti-malarial drug is obtained from the bark of Cinchona tree

Penicillin: Famous antibiotic is derived from Penicillium, a fungus

Tetracycline: Obtained from Bacterium
Vinblastine and Vincristine: Anti-cancer drugs obtained from Catharanthus plant which has anti-cancer alkaloids

High consumptive use values on resources may lead to the following problems:

1. Over-exploitation of wildlife in developing countries
2. Loss of traditional controls on hunting and
3. Loss of wildlife populations at productive levels.

Productive use value: Productive use value refers to products that are commercially harvested (sold in a national and international market). Many industries are dependent upon these values.

Textile, Leather, Silk, Paper and Pulp industry etc. Productive use value is often the only value of biological resource reflected in national income accounts and may have a major impact on the national economy.

Indirect values of biodiversity

Biodiversity provides the benefits to human beings supporting the existence of biological life and other benefits which are difficult to quantify. These include the following values

Social and cultural value: Many plants and animals are considered holy and sacred in India and are worshiped like tulsi, peepal, cow, snake etc. In Indian society great cultural value is given to forest and tiger, peacock and lotus are named as national animal, bird and flower respectively

Existence value or Ethical Value: These values are associated with conservation of biodiversity where ethical issue of “all life forms must be preserved” is laid down. There is an existence value which is associated to each species because biodiversity is valuable for the survival of human race.

Optional value: This refers to the potential of biodiversity that is currently known and needs to be explored. This refers to the idea that there may be several existing species that may prove to be important in future and their usefulness needs to be studied with reference to a specific problem currently plaguing the society.

Example:

1. The growing biotechnology field is searching for the cure for diseases like cancer and AIDS.
2. Medicinal plants and herbs play a very important role in the economic growth of our country.

Aesthetic Values: There is a great aesthetic value which is attached to biodiversity. Natural landscapes at undisturbed places are a delight to watch and also provide opportunities for recreational activities like bird watching, photography etc. Beautiful plants and animals inspire us to protect biodiversity. The most important aesthetic value of biodiversity is eco- tourism. Eco-tourism further generates revenue by designing of zoological, botanical gardens, national parks, wildlife conservation etc.

Ecosystem services value:

- Production of oxygen by land-based plants and marine algae.
- Maintenance of fresh water quality by vegetation slowing run off, trapping sediment and

removing nutrients and by soil organisms breaking down pollutants.

- Production and maintenance of fertile soil as a result of many interacting processes.
- Provision of foods such as fish, pastures for cattle and sheep, timber and fire wood.
- Maintenance of habitat that are attractive to humans for recreation, tourism and cultural activities and that has spiritual importance.
- Pollination of agricultural crops, forest trees and native flowering plants by native insects, birds and other creatures.
- Breakdown of pollutants by micro-organisms in soil and aquatic ecosystems and sequestration of heavy metals in marine and fresh water sediments.

THREATS TO BIODIVERSITY

Any disturbance in a natural ecosystem tends to reduce its biodiversity. Waste generated due to increase in human population and industrialization spoils the environment and leads to decreased diversity in biological species. Any change in the system leads to a major imbalance and threatens the normal ecological cycle. Causes for loss of biodiversity are:

1. Habitat loss
2. Poaching of wildlife and
3. Man-wildlife conflicts

Habitat loss:

The loss of populations of interbreeding organisms is caused by habitat loss. Factors influencing habitat loss are:

1. **Deforestation:** Loss of habitat is mainly caused by deforestation activities. Forests and grasslands are cleared for conversion into agriculture lands or settlement areas or developmental projects. Forests and grasslands are natural home to thousands of species which disintegrate due to loss of their natural habitat.
 2. **Destruction of wetlands:** Wetlands, estuaries and mangroves are destroyed due to farming, filling and pollution that cause loss of biodiversity
 3. **Habitat fragmentation:** When the habitat is divided into small and scattered patches the phenomenon is called habitat fragmentation. This leads to the disappearance of most wildlife
 4. **Raw material:** To produce hybrid seeds, wild plants are used as raw materials leading to extinction of many wild plant species.
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5. **Production of drugs:** Pharmaceutical companies collect wild plants for the production of drugs leading to extinction of several medicinal plant species.
6. **Developmental activities:** Construction of dams in forest areas coupled with the discharge of industrial effluents kills birds and other aquatic life.



Poaching of wildlife:

Poaching refers to killing animals or commercial hunting. It contributes to loss of biodiversity. Poaching can be of two types listed below:

- **Subsistence poaching:** This refers to killing animals for survival.
- **Commercial poaching:** This refers to hunting animals in order to sell their products.

Factors influencing poaching

1. **Human population:** Increased human population in India has led to pressure on forest resources, leading to degradation of wildlife habitats.
2. **Commercial activities:** Although a ban has been imposed internationally on the trade of products of endangered species, there is a continued smuggling of wildlife products. Since trading of such products is highly profitable, poachers continue to hunt endangered animals and smuggle their fur, skin and tusks to other countries.

Wildlife products include *furs, horns, tusks, live specimens and herbal products*. Richest source of biodiversity lies in developing nations in *Asia, Africa and Latin America*.

Advanced countries like Europe, North America, Japan, Taiwan, Hong Kong are the major importers of wildlife products.

MAN-WILDLIFE CONFLICTS

Man-wildlife conflicts arise, when wildlife starts causing immense damage and danger to man. Under such conditions it is very difficult for the forest department officials to convince the affected villagers to gain the support of villagers for wildlife conservation.

Examples:

1. In Sambalpur, Orissa, several people were killed by elephants. In retaliation, the villagers killed and injured several elephants.
2. In Mysore, elephants were killed by farmers in retaliation to the damage done by elephants to their cotton and sugarcane fields.
3. Villagers sometimes hide explosives in their fields to ward-off animals which explode when the elephants enter the fields
4. Several people were killed when leopards attacked them in Sanjay Gandhi National Park, Mumbai

Factors influencing man-animal conflicts

1. Shrinking forest cover compels wildlife to move outside the forest
2. Human encroachment into forest area induces a man-wildlife conflict
3. Injured animals have a tendency to attack man
4. Wild animals venture out of the forest area in search of food
5. Villager's set-up electric wiring around their fields. This injures animals (Elephants) who suffer in pain and get violent.
6. Cash compensation paid by the government is not enough.
7. Garbage near human settlements or food crops attracts wild animals

CONSERVATION OF BIODIVERSITY

The enormous value of biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve biodiversity. Gradually we are coming to realize that wildlife is not just

- ‘ a game to be hunted
- ‘ gift of nature
- ’ to be nurtured and enjoyed.

A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife.

There are two approaches of biodiversity conservation:

- (i) In-situ conservation
- (ii) Ex-situ conservation
- (i) **In-situ (on site) conservation** includes the protection of plants and animals within their natural habitats or in protected areas. Protected areas are areas of land or sea dedicated to protection and maintenance of biodiversity. For example: e.g., National Parks, Wildlife Sanctuaries, Biosphere Reserves, etc.
 - ✓ Biosphere reserves
 - ✓ National parks
 - ✓ Wildlife sanctuaries
 - ✓ Gene sanctuaries

Biosphere reserves cover large areas (>5000 sq.km.) They are normally used to protect species for a long time. The roles of biosphere reserves are listed below:

1. Long-term survival of evolving ecosystem
2. Protect endangered species
3. Protect maximum number of species and communities
4. Serve as site of recreation and tourism
5. May also be used for educational and research purposes.

Biosphere reserves function as an open system and changes in land use are not allowed. No tourism and explosive activities are allowed in biosphere reserves.

A national park is an area dedicated for the conservation of wildlife along with its environment. It covers an area ranging from 100 to 500 sq.km. One or more national parks may exist within a biosphere reserve.

- A national park is used for enjoyment through tourism, without affecting the environment.
- It is used to protect, propagate and develop wildlife.
- Grazing domestic animals inside national parks is prohibited
- All private rights and forestry activities are prohibited inside a national park.

A National Park is an area dedicated for the conservation of wildlife along with its environment. It is also meant for enjoyment through tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of

wildlife along with others.

Name of National Park	State	Important Wildlife
Kaziranga	Assam	One horned Rhino
Gir National Park	Gujarat	Indian Lion
Dachigam	J & K	Hangul
Bandipur	Karnataka	Elephant
Periyar	Kerala	Elephant, Tiger
Kanha	M.P.	Tiger
Corbett	U.P.	Tiger
Dudwa	U.P.	Tiger
Ranthambore	Rajasthan	Tiger
Sariska	Rajasthan	Tiger

Wildlife sanctuaries are also protected areas where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority. However, private ownership rights are permissible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely.

Many National Parks and Sanctuaries have been established to preserve wildlife in their natural environment. Some of them are given below along with the important species found in these.

- ✓ Kaziranga sanctuary (Assam) – one-horned rhinoceros
- ✓ Manas sanctuary (Assam) – wild buffaloes
- ✓ Gir forest (Gujarat) – lions, chital, sambar, wild bears
- ✓ Kelameru bird sanctuary (Andhra) – pelicans and marine birds
- ✓ Dachigam sanctuary (Jammu and Kashmir) – Kashmir stags, Himalayan tahr, wild goats, sheep, antelopes
- ✓ Bandipur sanctuary (Karnataka) – Indian bison, elephants, langurs
- ✓ Periyar sanctuary (Kerala) – elephants, barking deer, sambar
- ✓ Kanha National Park (Madhya Pradesh) – tiger, leopards, wild dogs
- ✓ Similipal National Park (Orissa) – mangroves, marine turtles lay eggs
- ✓ Bharatpur bird sanctuary (Rajasthan) – ducks, herons
- ✓ Corbett National Park (Uttaranchal) – tigers, barking deer, sambar, wild bear, rhesus monkey
- ✓ Jaladpara sanctuary (West Bengal) – rhinoceros.



Agencies Dealing with Conservation of Wildlife:

There are various agencies both at national and international levels which take care of conservation of wildlife. Some of them are given below

- (i) Indian Board for Wildlife (IBWL) advises state government on wildlife protection.
- (ii) Constitution of India includes forest and wildlife protection.
- (iii) **World Wildlife Fund for nature (WWF)** : It is an international organisation formed in the year 1961 and is engaged in protection of wildlife. India became a member of it in 1969 and has its headquarter in Mumbai. It has supported the well-known “Project Tiger”.
- (iv) International Union for Conservation of Nature and Natural resources (IUCN), World Conservation Union (WCU) is engaged in protection of wildlife and their habitats.
- (v) Convention of International Trade in Endangered Species (CITES) is an international organisation to check trade products from endangered animals. India became a party to CITES in 1976.

Advantages of in-situ conservation

1. It is cheap and convenient
2. Species get adjusted to natural disasters like drought, floods, forest fires etc.

Disadvantages of in-situ conservation

1. A large surface area of earth is required to preserve biodiversity
2. Maintenance is not proper due to shortage of staff and pollution

Ex-situ (off site) conservation is the conservation of plants and animals outside their natural habitats. These include Botanical Gardens, Zoo, Gene Banks, DNA Banks, Seed Banks, Pollen Banks, Seedling and Tissue Culture etc.

Ex situ Conservation: This type of conservation is mainly done for conservation of crop varieties, the wild relatives of crops and all the local varieties with the main objective of

conserving the total genetic variability of the crop species for future crop improvement or afforestation programmes. In India, we have the following important gene bank/seed bank facilities.

- (i) **National Bureau of Plant Genetic Resources (NBPGR)** is located in New Delhi. Here agricultural and horticultural crops and their wild relatives are preserved by cryo-preservation of seeds, pollen etc. by using liquid nitrogen at a temperature as low as -196°C . Varieties of rice, pearl millet, Brassica, turnip, radish, tomato, onion, carrot, chilli, tobacco, poppy etc. have been preserved successfully in liquid nitrogen for several years without losing seed viability.
- (ii) **National Bureau of Animal Genetic Resources (NBAGR)** located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.
- (iii) **National Facility for Plant Tissue Culture Repository (NFPTCR)** for the development of a facility of conservation of varieties of crop plants/trees by tissue culture. This facility has been created within the NBPGR.

The G-15 countries have also resolved to set up a network of gene banks to facilitate the conservation of various varieties of aromatic and medicinal plants for which India is the networking coordinator country.



Advantages of Ex-situ conservation

- 1. Survival of endangered species is increasing due to special care and attention
- 2. In captive breeding the animals are assured of food, water, shelter and security thereby have a longer life span
- 3. It is carried-out in cases of endangered species that do not have any chance of survival in the wild.

Disadvantages of Ex-situ conservation

- 1. It is an expensive method

2. Freedom of wildlife is lost
3. Animals cannot survive in the natural environment.

ENDANGERED SPECIES OF INDIA:

A plant, animal or microorganism that is in immediate risk of biological extinction is called endangered species or threatened species. In India, 450 plant species have been identified as endangered species. 100 mammals and 150 birds are estimated to be endangered. India's biodiversity is threatened primarily due to Habitat destruction, Degradation and over exploitation of resources. The International Union for Conservation of Nature (IUCN) RED-data book contains a list of endangered species of plants and animals. It contains a list of species of that are endangered but might become extinct in the near future if not protected. Some of the rarest animals found in India are Asiatic cheetah, Asiatic Lion, Asiatic Wild Ass, Bengal Fox, Indian Elephant, Indian Rhinoceros, Marbled Cat and Markhor.

Extinct species are the species that are no longer found in the world.

Endangered or threatened species is one whose number has been reduced to a critical number. Unless it is protected and conserved, it is in immediate danger of extinction.

Vulnerable species is one whose population is facing continuous decline due to habitat destruction or over exploitation. However, it is still abundant.

Rare species is localized within a restricted area or is thinly scattered over an extensive area. Such species are not endangered or vulnerable. A few endangered species in the world are such as West Virginia Spring Salamander (U.S.A), Giant Panda (China), Golden Lion Tamarin (Brazil), Siberian Tiger (Siberia), Mountain Gorilla (Africa), Pine Barrens Tree Frog (Male). Other important endangered species are Tortoise, Green sea Turtle, Gharial, Python (Reptiles), Peacock, Siberian White Crane, Pelican, Indian Bustard (Birds).

Endemic species of India Species that are found only in a particular region are known as endemic species. Almost 60% the endemic species in India are found in Himalayas and the Western Ghats. Endemic species are mainly concentrated in North-East India, North-West Himalayas, Western Ghats and Andaman & Nicobar Islands.

Factors affecting endemic species:

1. Habitat loss and fragmentation due to draining and filling of inland wetlands.
2. Pollution also plays an important role.

A few species of endangered reptiles, birds, mammals and plants are given below:

- (a) Reptiles: Gharial, green sea turtle, tortoise, python
- (b) Birds: Great Indian bustard, Peacock, Pelican, Great Indian Hornbill, Siberian White Crane.
- (c) Carnivorous: Indian wolf, red fox, Sloth bear, red panda, Mammals tiger, leopard, striped hyena, Indian lion, golden cat, desert cat, dugong
- (d) Primates: Hoolock gibbon, lion-tailed macaque, Nilgiri langur, Capped monkey, golden monkey
- (e) Plants : A large number of species of orchids, Rhododendrons, medicinal plants like *Rauvolfia serpentina*, the sandal wood tree *Santalum*, *Cycas beddomei* etc.

The Zoological Survey of India reported that Cheetah, Pink headed duck and mountain quail have already become extinct from India. A species is said to be extinct when it is not seen in the wild for 50 years at a stretch e.g. Dodo, passenger pigeon. A species is said to be endangered when its number has been reduced to a critical level or whose habitats, have been drastically reduced and if such a species is not protected and conserved, it is in immediate danger of extinction. A species is said to be in vulnerable category if its population is facing continuous decline due to overexploitation or habitat destruction. Such a species is still abundant, but under a serious threat of becoming endangered if causal factors are not checked. Species which are not endangered or vulnerable at present, but are at a risk are categorized as rare species. These taxa are usually localized within restricted areas i.e. they are usually endemic. Sometimes they are thinly scattered over a more extensive area.

Some important endangered and extinct species are shown in Plate.



Passenger pigeon



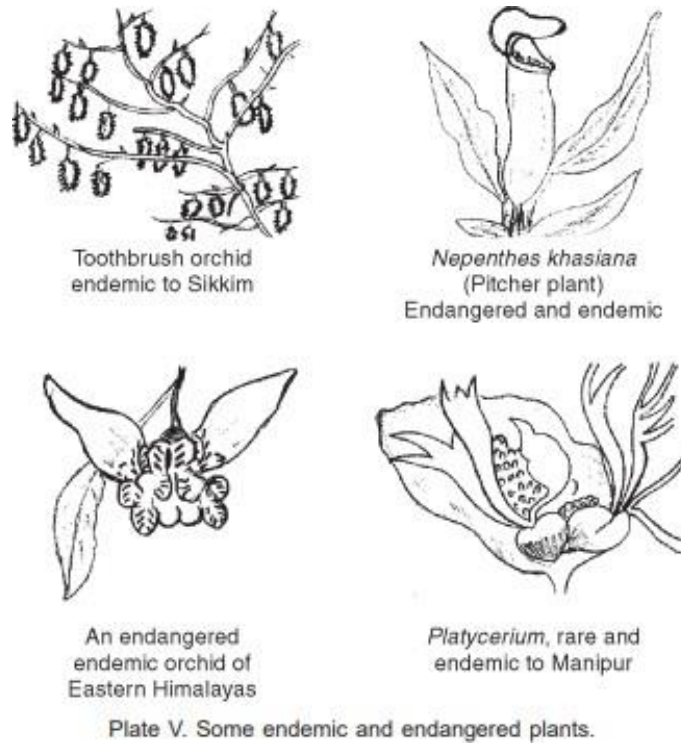
Dodo

Extinct



ENDEMIC SPECIES OF INDIA

India has two biodiversity hot spots and thus possesses a large number of endemic species. Out of about 47,000 species of plants in our country 7000 are endemic. Thus, Indian subcontinent has about 62% endemic flora, restricted mainly to Himalayas, Khasi Hills and Western Ghats. Some of the important endemic flora include orchids and species like *Sapria himalayana*, *Uvaria lurida*, *Nepenthes khasiana*, *Pedicularis perroter* etc. Some endemic plant species are shown in Plate V. A large number out of a total of 81,000 species of animals in our country is endemic. The western ghats are particularly rich in amphibians (frogs, toads etc.) and reptiles (lizards, crocodiles etc.). About 62% amphibians and 50% lizards are endemic to Western Ghats. Different species of monitor lizards (*Varanus*), reticulated python and Indian Salamander and Viviparous toad *Nectophryne* are some important endemic species of our country.



ECOSYSTEM : “Eco-system is defined as a self-regulating group of biotic communities of species interacting with their non-living environment exchanging energy and matter.” Study of ecosystems is called as **Ecology** or the study of organisms in their natural home interacting with their surroundings is called Ecology.

Ecology – earnest Haeckel- 1869 –derived from “oikos” – home, logy – study-deals with the study of organisms in their natural home interacting with their surroundings. Ecosystem – Tansley (1935) – self-regulating group of biotic communities of species interacting with one another and with their non- living environment exchanging energy and matter.

ECOSYSTEM CHARACTERISTICS:

Structural features – composition and organization of biological communities and abiotic components constitute – Structure of Ecosystem.

Biotic structure – Plants, animals, microorganisms – form biotic components – nutritional behavior and status in the ecosystem – producers or consumers – how do they get their food.

STRUCTURE OF ECO-SYSTEM

The structural attributes (components) of these components are:

- Biotic components
- Abiotic components

Interaction of biotic and abiotic components result in a physical structure that is characteristic for each type of ecosystem. Identification and enumeration of plant and animal species of an ecosystem gives its species composition. Vertical distribution of different species occupying different levels is called stratification. For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layers.

1. Biotic components:

These constitute all the living members of an eco-system. Ex. Plants, animals and microorganisms. These are of three types:

- Producers
- Consumers
- Decomposers

Producers- These are constituted mainly by green plants. Green plants trap solar energy and converts into potential chemical energy in the process called photosynthesis. These species are also known as Photo- autotrophs. The plant species which live inside the ocean waters prepare their food in the absence of sunlight by the oxidation of chemicals and they are known as chemo-autotrophs and the process is called chemosynthesis. (Sulphur bacteria)

Consumers- Organisms which get their food by feeding on other organisms are called consumers.

- a. Herbivores- they feed on plant species (primary producers) eg- rabbit, insects
- b. Carnivores- they food on herbivores and other carnivores eg- frog, snake
- c. Omnivores- they feed on both plants and animals. Eg- humans
- d. Detritivores- they feed on parts of dead organisms, waste of living organisms etc. Eg: earthworms, ants.

Decomposers- they derive their food by breaking down the complex organic molecules to simple organic compounds and finally to inorganic nutrients. Eg- bacteria, fungi.

2. Abiotic components: - Abiotic components of an eco-system consist of non living substances and factors. They are broadly divided into Physical and chemical factors.

- Physical factors include temperature, wind, soil type, water availability, humidity, precipitation, light, etc.
- Chemical factors include nutrients like Carbon, Nitrogen, Phosphorous, potassium, topography, pH of the soil, etc.

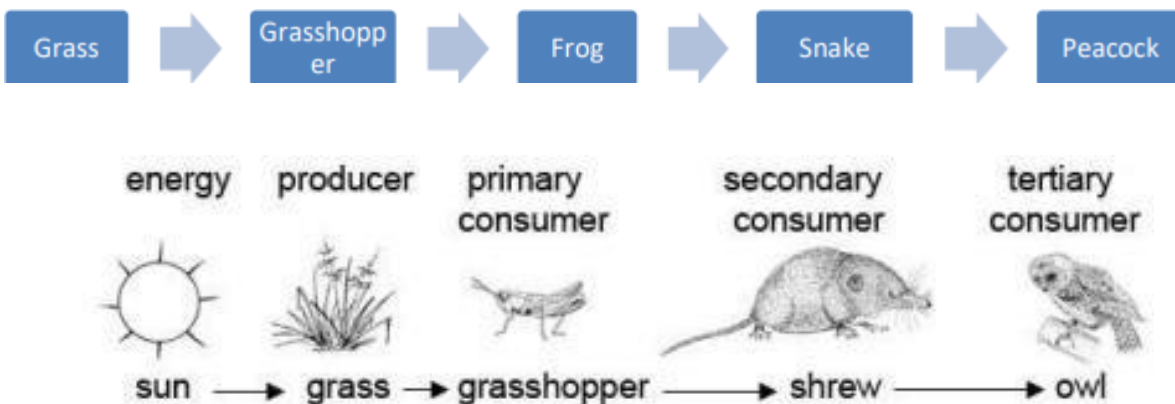
FUNCTIONS OF ECO-SYSTEM:

Eco-systems have some functional attributes due to which components remain and running together. The tendency of every eco-system depends on various function performed by the structural components of the eco-system.

The main functional attributes of eco-system are:

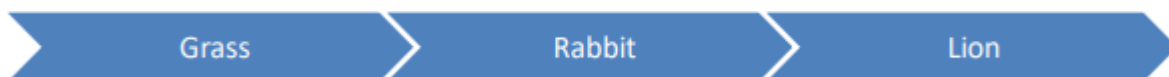
- I. Food Chain & Food Web.
- II. Energy flow
- III. Ecological pyramids
- IV. Ecological regulation
- IV. Ecological succession

Food chain: The transfer of food, energy from producers through a series of organisms with repeated eating and being eaten is known as a food chain.

**Types of food chains:**

There are 2 types of food chains:

- a. **Grazing food chain:** This type of food chain starts from the living green plants goes to grazing herbivores and onto carnivores, eco-systems with such type of food chains are directly depend upon the influx of the solar radiation. Most of the eco-systems in nature follow this type of food chain.



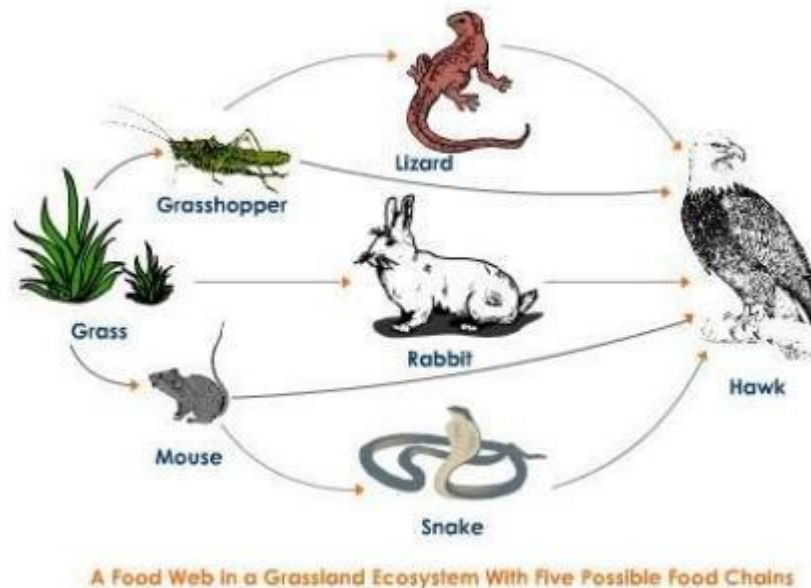
- b. **Detroiter's food chain:** This type of food chain goes from dead organic matter into microorganisms and then to organisms which feed on detritivors (decomposers) and

predators. Such eco-systems are not dependent on direct solar energy and chiefly depend upon the influx of dead organic matter produced in other eco-systems. Ex: bacteria and fungi feeding on dead organic matter and are eaten by small fish which act as prey to large fish or birds.



Food webs: A complex network of interconnected food chains of different trophic levels in a Biotic community is termed as a food web. The complexity of any food web depends upon the diversity of organisms in that ecosystem. Thus, each species of any eco-system is indeed kept under some sort of a natural check so that the eco-system may remain balanced and this is the significance of a food web.

Example:



Significance of food chain & food web

- They maintain the ecological balance by regulating the nutrient cycles.
- Biological magnification- It is a process in which the concentration of the nonbiodegradable material or any fertilizer accumulates in the food chain. As human beings occupy the highest position in the trophic level, they get highly bio-magnified which is harmful. Ex:- DDT (dichloro diphenyl trichloro ethane) is an insecticide used for killing insects. Excess usage of this non-biodegradable chemical makes the soil over nourished and its concentration increases as it

passes along the food chain.

II. Energy flow- All eco-systems are energy driven complexes. The energy concerned to eco-system is light energy, chemical energy, heat energy and the source of all these energies is “solar energy”. This energy gradually transfers to light, chemical and heat energy. 1% of total energy falling on plants used for photosynthesis and this is only source of energy for proper functioning of the eco-system. The fixation of solar energy by the plants and its utilization in the form of food by living organisms obey the 2 laws of thermodynamics.

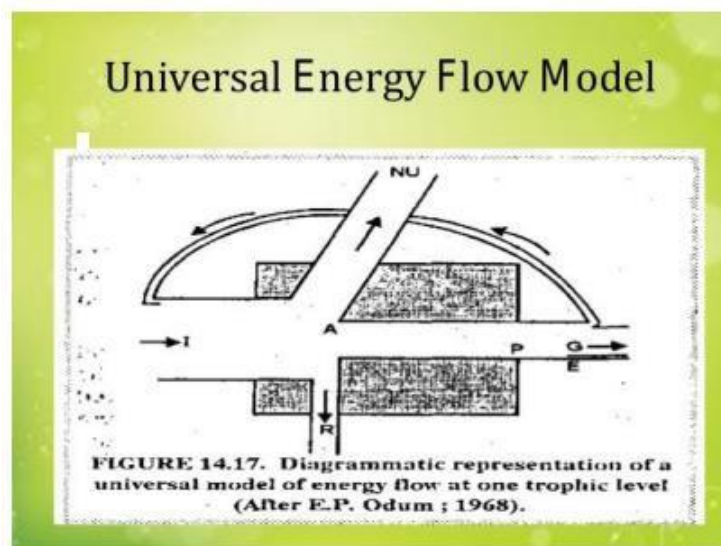
1st law: Energy can neither be created nor destroyed; it can only transfer from one form to another.

2nd law: It states that every transformation of energy is accompanied by a simultaneous degradation of energy from concentrated form to disperse. Flow of energy is always uni-directional.

Energy Flow Models: Energy flow in various trophic levels of an ecosystem can be explained with the help of various energy flow models. They are;

- A. Universal Energy Flow Model
- B. Single Channel Energy Flow Model
- C. Double channel or Y-shaped flow model.

Universal energy flow model: This model tells, as the energy flow takes place, there is a gradual loss of energy at every level as indicated in the picture. This occurs mainly due to respiration, locomotion and other metabolic activities.



Single energy flow model: The flow of energy takes place in a unidirectional manner through a single channel of producers to top carnivores, and illustrated the gradual decline in energy level due to loss of energy at each successive trophic level in a grazing food chain.

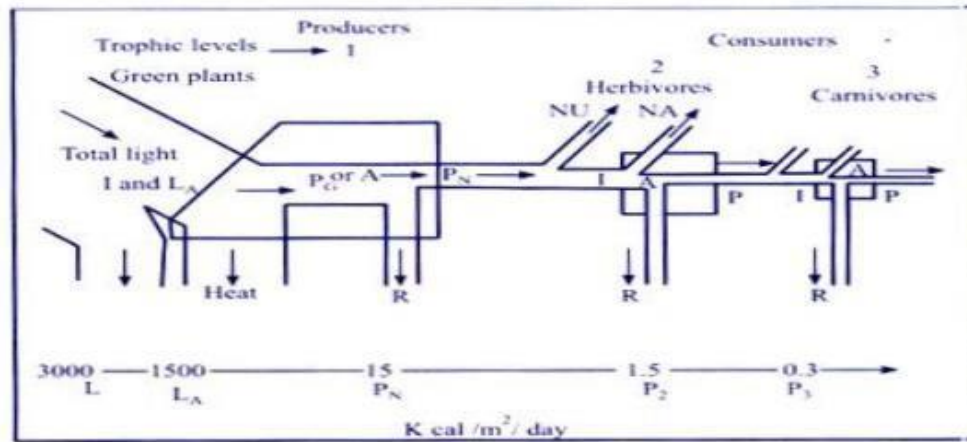


Fig. 1.4 A simplified energy flow diagram depicting three trophic levels

Double channel or Y-shaped flow model: In nature, both grazing and detritus food chain operate in the same ecosystem. However, it is the grazing food chain which predominates. The double channel or Y-shaped flow model of energy flow shows the passage of energy through two food chains which are separated in time and space.

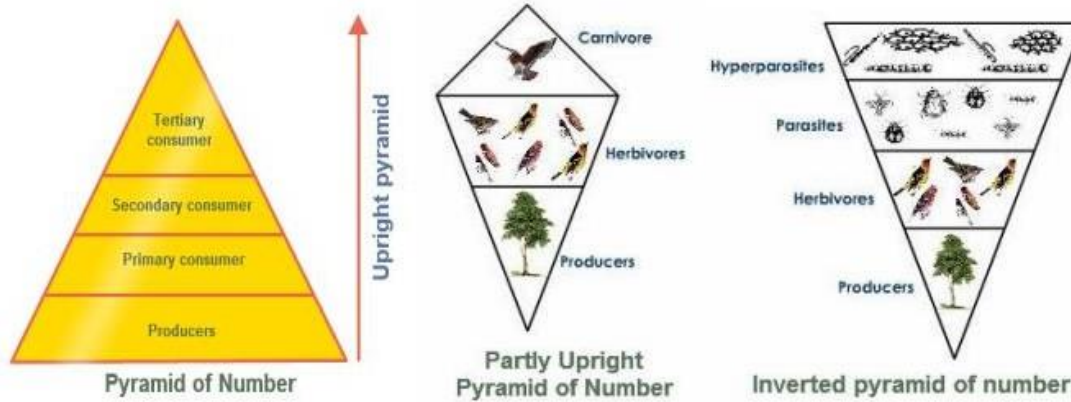
III. Ecological pyramids: The graphical representation of structure and function of trophic levels of an ecosystem, starting with producers at the top and each successive trophic level forming the apex is known as an ecological pyramid. In a food chain starting from the producers to the consumers, there is a regular decrease in the properties (i.e., energy, biomass and the number of organisms). Since some energy is lost in each trophic level, it becomes progressively smaller at the top.

Ecological pyramids are of three types:

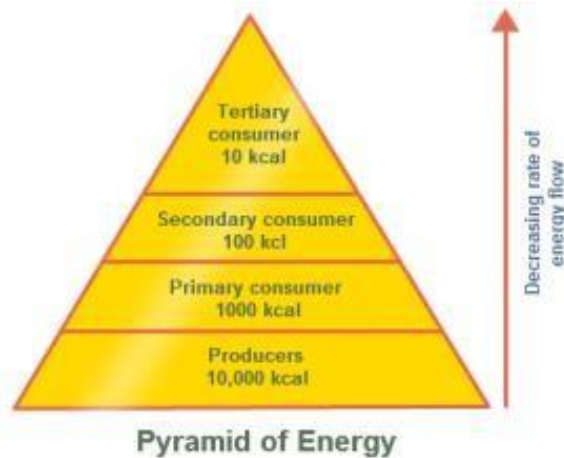
1. Pyramid of Numbers
2. Pyramids of Energy and
3. Pyramid of Biomass

Pyramid of Numbers: It represents the number of individual organisms present in each trophic level. Ex: A grassland Ecosystem Producers are grass (small in size and large in number. Hence they occupy the first trophic level. The primary consumers are rats occupying the second trophic level. It is worthwhile to note that rats are less in number than grass. Secondary consumers are

snakes which occupy the third trophic level and they are lesser in number than rats. Tertiary consumers are Eagles that occupy the next trophic level. This is the last trophic level where the number and size of the trophic level is the least as shown in the diagram.

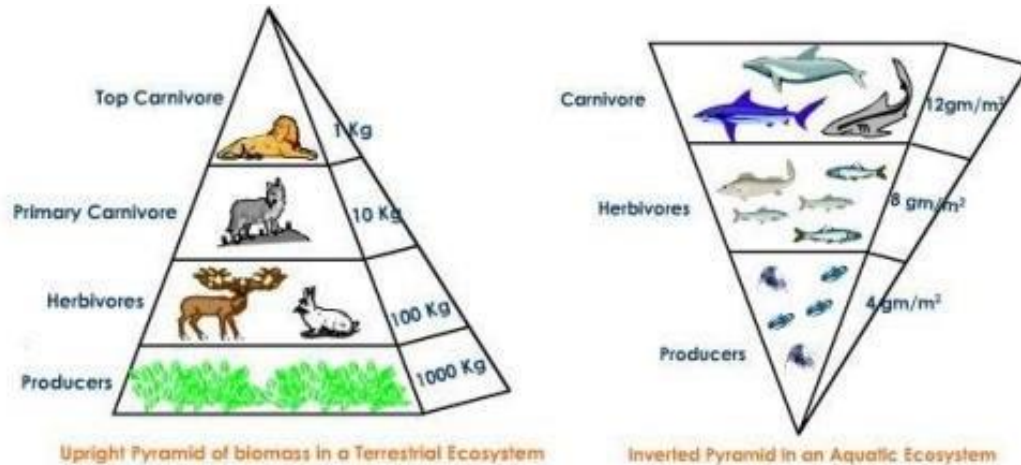


Pyramid of Energy : It represents the amount of energy present in each trophic level. The rate of energy flow and the productivity at each successive trophic level is shown in the figure below. At every successive trophic level, there is a heavy loss of energy (almost 90%) in the form of heat. Thus, at each trophic level only 10% is transferred. Hence there is a sharp decrease in energy at each and every successive trophic level as we move from producers to top consumers (carnivores). Pyramid of energy is depicted in the figure below.



Pyramid of Biomass: It represents the total amount of biomass (mass or weight of biological material) present in each trophic level. Considering the example of a forest ecosystem, there is a steady decrease in the biomass from the lower trophic level to the higher trophic level. The producers (trees) contribute a major amount of the biomass. The next trophic levels are the

herbivores (insects and birds) and carnivores (snakes, foxes, etc). The top of the trophic level consists of very few tertiary consumers (Ex: Lions and Tigers) whose biomass is very low. The pyramid of biomass is shown below.



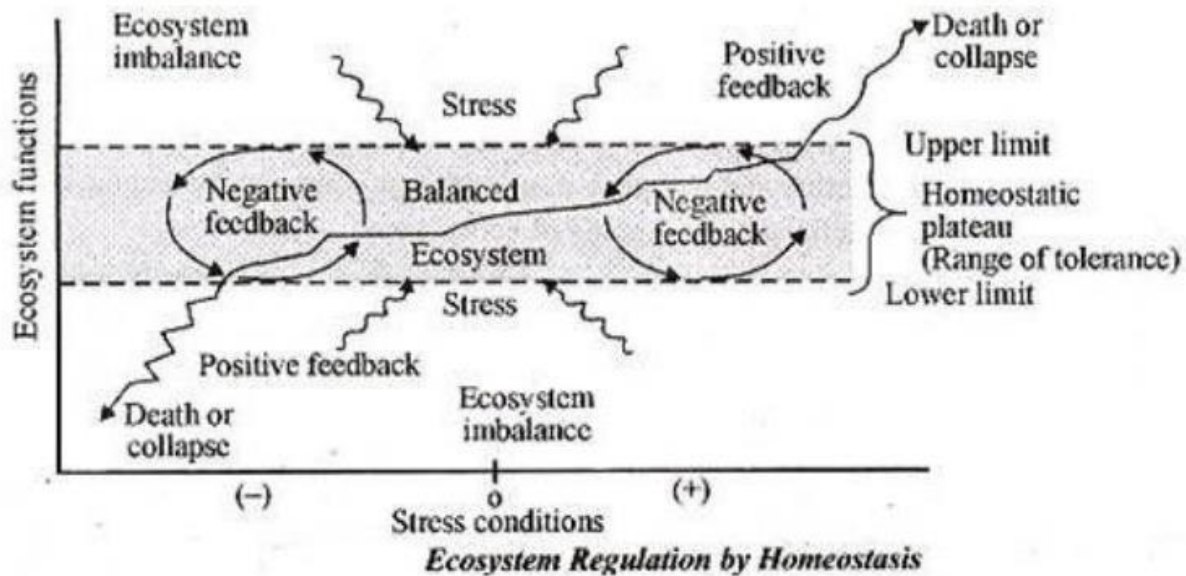
Ecological production: The rate of production of organic matter or biomass is called productivity.

This is of 2 types:

- i) **Primary productivity:** it is defined as the rate at which the radiant energy is converted into organic substances by photosynthesis or chemo-synthesis by the primary producers. It is of 2 types: GPP (Gross Primary Productivity): The rate at which the producers are able to utilise the radiant energy in photo or chemo synthesis to produce their food is called GPP. NPP (Net Primary Productivity): The rate at which the energy or organic matter is stored in a producer after respiration is called NPP. Thus, $NPP = GPP - R$ (R= Respiratory loss)
- ii) **Secondary productivity:** The energy stored at consumer level for use by the next trophic level is known secondary production.

IV. Ecosystem Regulation: Ecosystem itself tries to resist to any environmental stress tries to disturb the normal ecosystem and maintain the equilibrium with the environment. This property is known as Homeostasis. However, the system can show this tolerance or resistance only within a maximum and a minimum range, which is known as Homeostatic Plateau. Within this range, if any stress tries to cause a deviation, then the system has its own mechanism to counteract these deviations which are known as Negative Feedback Mechanisms. These negative feedback mechanisms try to bring the system back to its ideal conditions. But, if the stress is too high and beyond the range of homeostatic plateau, then another type of mechanism

known as Positive Feedback Mechanisms start operating and accelerate the deviations. So these kinds of mechanisms take the system away from its ideal conditions and leads to environmental disasters.



- V. **Ecological succession:** Any community tries to maintain the equilibrium with the prevailing condition of the environment. It changes with the changing environmental conditions. Sometimes the activities within the community itself or environmental changes can effect a change in the community. Eco-system development may be defined as “it is an orderly process of community development that involves changes in species structure of community processes.” Finally it ends in a stabilized eco-system. The community which develops as initial community is known as pioneer community. The transitory communities are called as “seral stages” or developed stages. When a system gets stabilized i.e. the final community which lasts for a longer period is known as “climax community”.

Process of succession: The whole process of succession is completed through a number of sequential steps which follows one another. Those are:

- Nudation
- Invasion
- Competition & co-action
- Reaction
- Stabilization

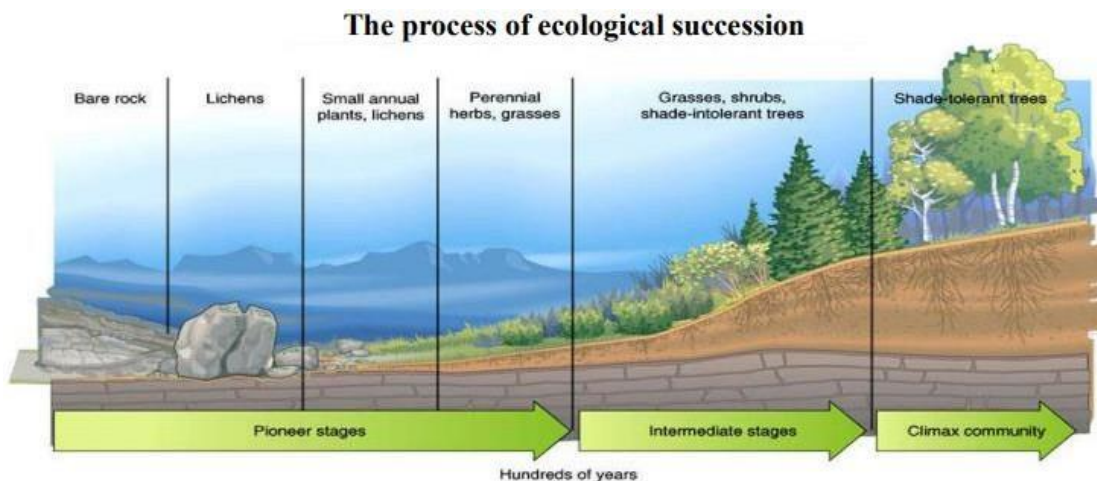
Nudation: This is the development of bare area without any form of life. This area may develop due to topographic (soil erosion by gravity, water, wind, land slides, volcanic activity, earth quakes etc.) or climatic like floods drought conditions, melting of glaciers, storms and biotic factors.

Invasion: This is the successful establishment of life in that area. The species actually reaches that area from other places the forces of migration and dispersal. After reaching the new area the process of successful establishment of species is known as “ecesis”. In plants seeds germinate, seedlings grow and adults start to reproduce and increase their number, this process is called “aggregation”.

Competition and co-action: After aggregation large number of individuals of species increase in a limited area, develops competition and co-action for space and nutrition. In this process changes within the community can be observed and the species is unable to compete with other number of individuals would be discarded.

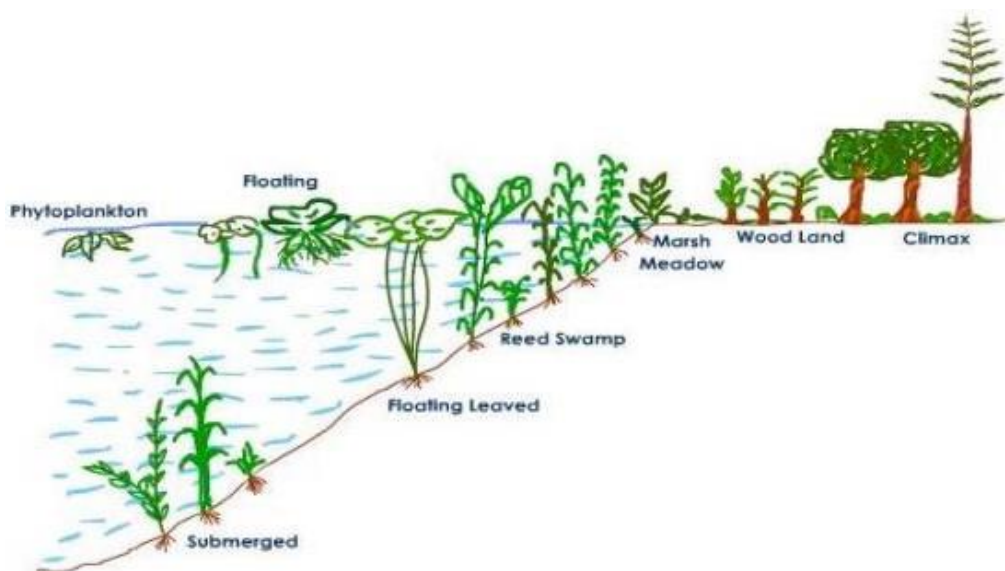
Reaction: This is the most important stage in the process of succession. The mechanism of modification of environment through the influence of living organisms starts in this stage. As a result of this process changes takes place in soil, soil structures, water ph, light conditions, temperature etc. of the environment. Due to all these the environment is modified and becoming unsuitable for the existing community which sooner or later is replaced by another community.

Stabilization: Finally there occurs a stage in the process. Then the final community or terminal community becomes more or less stabilized for a longer period of time and it can be maintain itself on equilibrium with the environment or surrounding or climate of the area.



Example of Ecological Succession:

- 1) Hydrosere (Hydrarch): This type of succession start in a water bodies like pond and culminates in a climax community which is forest. It has following stages: a) Phytoplankton stage: These are the pioneer community. Mainly blue green algae, green algae, diatoms and bacteria etc.
- 2) Rooted submerged stage: Due to death and decomposition of phytoplankton organic matter start accumulating on the pond subsurface. This new environment is favorable for the growth of rooted submerged hydrophytes like Hydrilla, Elodea etc.
- 3) Rooted submerged stage: Now the depth of lake reduces to 2-5 feet, favoring the growth of rooted hydrophytes with their large leaves floating on the water surface. Example: Nelumbo, Trapa, Azolla etc.
- 4) Reed-swamp stage: also known as amphibious stage as the plants of community are rooted but most of it part is in air. Example: Scirpus, Sagittaria etc.
- 5) Sedge-meadow stage: They form mat like vegetation, results into higher loss of water through evapotranspiration process. The marsh like condition in the previous stage is removed and area with soil moisture left. Example: carex, cyperus etc.
- 6) Woodland stage: As the marsh land disappear soil become more dry and give rise to vegetation like shrubs(Salix, cornus) and trees (populus, Alnus).
- 7) Forest stage: This is climax community. It can developed as tropical rain forest or mixed forest depending upon the climate of the region. Example: Ulmus, Acer and Quercus.



DIFFERENCE BETWEEN BIOTIC AND ABIOTIC COMPONENTS:

BIOTIC	VERSUS	ABIOTIC
Biotic refers to the living elements in an ecosystem		Abiotic refers to the non-living, physical elements in an ecosystem
Biotic elements depend on the abiotic elements for the survival		Abiotic elements do not depend on biotic elements within an ecosystem
Measurement is subjective		Measurement is objective
Affect the individual of a species, community, population, biosphere, and the biome		Affect the individual of a species, community, population, and biosphere
Living things directly or indirectly affect the other living things in the ecosystem		Abiotic elements determine the number of organisms, which are capable of existing in the environment
Have the ability to adapt changes in the environment		Unable to adapt to changes in the environment
Components include plants, animals, and microorganisms which serve as producers, consumers, and decomposers in an ecosystem		Components include climate, parent material and soil, topography and natural disturbances
Resources include forests and their products, animals, birds, and marine resources like fish		Resources include land, water, coal, and oil

TYPES OF ECOSYSTEMS

1. FOREST ECOSYSTEM

Definition: It is a natural ecosystem consisting of dense growth of trees and wild animals. Tropical rain forests → found near the equator, high temperature, have broad leaf trees like sandal, lion, tiger.

Tropical deciduous forest → Found away from equator, warm climate, deciduous trees like maple, oak, deer, fox, rabbit etc.

Temperate rain forests → adequate rainfall areas, coniferous trees like pines, firs, squirrels, fox, cats, bear etc.

Temperate deciduous forest → found in moderate temp., trees like oak, hickory, animals – deer, fox, bear etc.

Tropical scrub forests → dry climate for longer time, small deciduous trees & shrubs, animals – deer, fox etc.



Characteristics of forest ecosystem:

- Characterized by warm temperature, adequate rainfall
- Maintain climate & rainfall
- Support many wild animals & protect biodiversity
- Soil is rich in minerals, so support growth of trees
- Penetration of light is poor so conversion of organic matter is very fast.

GRASSLAND ECOSYSTEM: Dominated by grass –few shrubs and trees are also found – rainfall average but erratic – overgrazing leads to desertification.

Three types – depending on the climate

1. Tropical grass lands – found near the borders of tropical rain forests. Eg. Savannas in

Africa. Animals– Zebra, giraffes etc. – fires are common in dry seasons – termite mounds produce methane – leads to fire – high in photosynthesis – deliberate burning leads to release of high CO₂ – global warming.

2. Temperate grasslands – flat and gentle slopes of hills. Very cold winter and very hot summer. - dry summer fires do not allow shrubs and trees to grow – soil is quite fertile – cleaned for agriculture.

3. Polar grasslands – found in arctic polar region – organism – arctic wolf, fox, etc. – A thick layer of ice remains frozen under the soil surface throughout the year – known as permafrost – summer insects and birds appear.



Components:

Structural Components: I. Abiotic Components → abiotic components are physical components present in soil & atmosphere (Ex) temperature, light, rainfall, minerals

II. Biotic Components:

Producers → plants absorb sunlight & produce food by photosynthesis. Ex-trees, shrubs, plants
Consumers.

Primary consumers → Called herbivores/plant eaters- depend on plants for food. Ex. Insects, rat, goat, deer, cow, horse etc

Secondary consumers → Called primary carnivores/meat eaters. Depend on herbivores for food
Ex. Frog, birds, cat, snakes, foxes etc.

Tertiary consumers → Called Secondary carnivores, feed on secondary consumers. Ex. Tigers, lions etc.
Decomposers → Organisms which feed on dead organisms, plants & animals & decompose into simpler compounds Ex.

DESERT ECOSYSTEM

Desert occupies about 35% of our world's land area. It is characterised by less than 25 cm rainfall. The atmosphere is dry and hence it is a poor insulator.

Types:

1. Tropical desert-found in Africa-Sahara and Rajasthan – Thar
2. Temperate desert-south California-Majave
3. Cold desert-China-Gobi desert



Characteristics:

- 1 Air is dry
 - 2 Climate is hot
 - 3 Annual rainfall is less than 25 cm
 - 4 Vegetation is poor
- Structure and functions of the desert Ecosystems
- I. Abiotic Components - Eg. Temperature, rainfall, sunlight, water, etc.
 - II. Biotic Components
 1. **Producers** Eg. Shrubs, bushes, some grasses and few trees. In deserts mostly Succulent (e.g., cacti) plants are found available. They have waxy layer on the outside to protect them from the sun.
 2. **Consumers** Eg. Squirrels, mice, foxes, rabbits, deer and reptiles These animals dig holes in the ground to live in. Most of the animals can extract water from the seeds they eat.

AQUATIC ECOSYSTEM

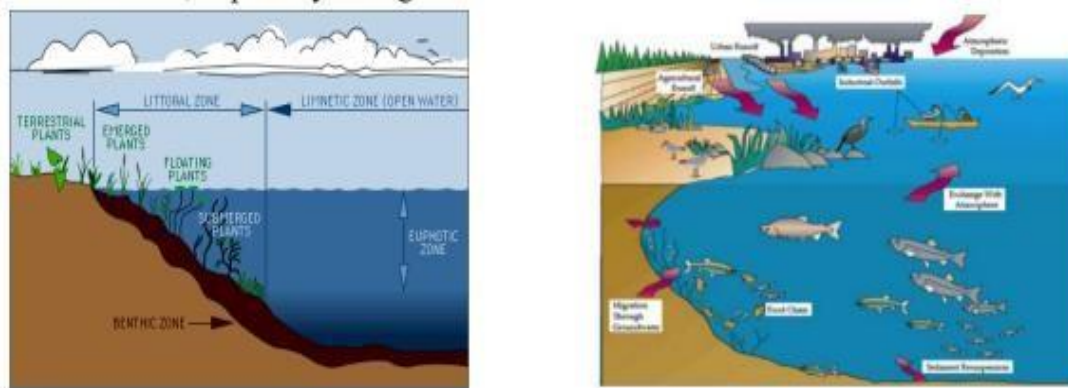
Definition: Deals with water bodies and biotic communities present in them- Classified as fresh water and marine ecosystems. Fresh water systems are classified as lentic and lotic ecosystems.

Types:

1. Pond ecosystem: Small fresh water ecosystem – seasonal in nature – organisms: algae, aquatic plants, insects, fishes etc. Ponds are very often exposed to anthropogenic pressure like

cloth washing, bathing, cattle bathing, swimming etc.

2. Lake ecosystem: Big fresh water ecosystem – Zonation or stratification, Especially during summer is a common one.



Top layer – shallow, warm, prone to anthropogenic activities – Littoral Zone

Second layer – enough sunlight, high primary productivity Limnetic zone

Third layer – very poor or no sunlight

Profundal zone Eg. Dal lake in Srinagar, Naini lake in Nainital

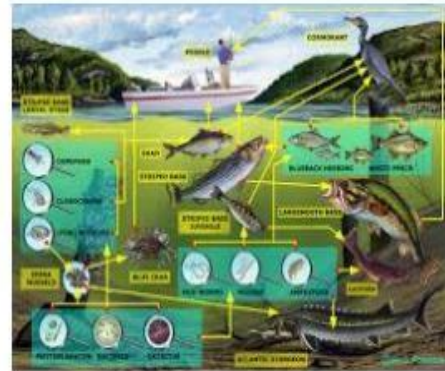
Organisms: planktons – phytoplankton eg. Algae – zooplankton eg. Rotifers Nektons – that swims in water eg. Fishes Neustons – that float on the surface of water Benthos – that attached to sediments eg. Snails.

Types of lakes: Many types- oligotrophic lakes – with less nutrient content – Eutrophic lakes – with very high nutrient content due to fertilizer contamination – desert salt lakes – that contains high saline water due to over evaporation – volcanic lakes – formed by water emitted from magma due to volcanic eruptions – dystrophic lakes – that contains highly acidic water (low pH) – endemic lakes – lakes that contain many endemic species etc.

3. **Streams:** fresh water ecosystem where water current plays a major role. Oxygen and nutrient content are uniform. Stream organisms have to face extreme difference in climatic conditions but they do not suffer from oxygen deficiency as pond and lake organisms. This is because large surface area of running water provides more oxygen supply. The animals have very narrow range of tolerance towards oxygen deficiency. Thus stream are worst victims of industrial pollution.

River Ecosystem: large streams flowing from mountain highlands are rivers.

Three phases: 1. mountain high lands – rushing down water fall of water – large quantity of dissolved oxygen – plants attached to rocks and fishes that require more oxygen are found. 2. Second phase – gentle slopes of hills – warmer – supports the growth of plants and fishes that require less oxygen are seen. 3. Third phase: river shapes the land – lots of silts, nutrients are brought – deposited in plains and delta – very rich in biodiversity.



OCEANS ECOSYSTEM

Gigantic reservoirs of water covering >70% of earth surface – 2,50,000 species – huge variety of sea products, drugs etc. – provide Fe, Mg, oils, natural gas, and etc. – major sinks of carbon di oxide – regulate biochemical cycles.

Two zones: coastal zone – warm, nutrient rich, shallow – high sunlight – high primary productivity. Open sea – away from continental shelf – vertically divided in to zones.

1. euphotic zone – abundant sunlight
2. bathyal zone – dim sunlight
3. abyssal one dark zone – world's largest ecological unit.



Characteristic features of Ocean Ecosystem

1. It occupies a large surface area with saline water & rich in biodiversity
2. Since ship, submarines can sail in ocean, commercial activities may be carried out.
3. It moderates the temperature of the earth. Structure and function of Ocean Ecosystems

Abiotic Components - Eg. Temperature, light, NaCl, K, Ca, and Mg Salts, alkalinity.

Biotic Components

1. Producers - Eg. Phytoplanktons (diatoms, unicellular algae, etc.) and marine plants (sea weeds, chlorophyceae, phaeophyceae).

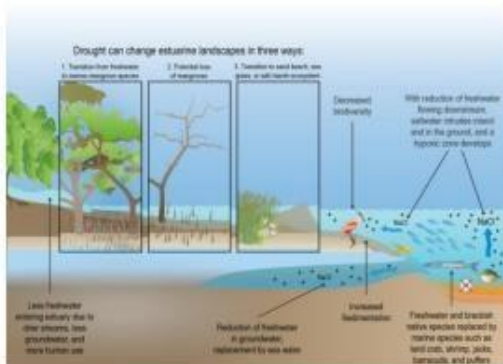
2. Consumers

- Primary Consumer - Eg. Crustaceans, molluscs, fish.
- Secondary Consumer - Eg. Herring, shark, mackerel
- Tertiary Consumer – Eg. Cod, Haddock, etc.,

3. Decomposers - Eg. Bacteria and some fungi.

ESTUARY ECOSYSTEM

Coastal area where river meet ocean – strongly affected by tidal actions – very rich in nutrients – very rich in biodiversity also – organisms are highly tolerant – many species are endemic – high food productivity – however to be protected from pollution.



Characteristics: Structural Components: Abiotic: pH, nutrients, D.O, temp, climatic conditions, etc. Biotic: Phytoplankton, fishes, snails insects, birds, etc.

Energy flow:

Phytoplankton ◇ Insects ◇ small fishes ◇ huge fishes

LOTIC ECOSYSTEM

- ❑ Lotic ecosystems are the systems with rapid flowing waters that move in a unidirectional way such as rivers and streams.
- ❑ These environments harbor numerous species of insects such as mayflies, stoneflies and beetles which have developed adapted features such as weighted cases to survive the environment.
- ❑ Several species of fishes such as eel, trout and minnow are found here. Various mammals such as beavers, otters and river dolphins inhabit lotic ecosystems.

**LENTIC ECOSYSTEM**

- ❑ Lentic ecosystems include all standing water habitats such as lakes and ponds.
- ❑ These ecosystems are home to algae, rooted and floating-leaved plants and invertebrates such as crabs and shrimps.
- ❑ Amphibians such as frogs and salamanders and reptiles like alligators and water snakes are also found here.



WETLAND ECOSYSTEM

- ☐ Wetlands are marshy areas and are sometimes covered in water which have a wide diversity of plants and animals.
- ☐ Swamps, marshes, and bogs are some examples in this regard. Plants such as black spruce and water lilies are commonly found in wetlands.
- ☐ The fauna consists of dragonflies and damselflies, birds such as Green Heron and fishes such as Northern Pike.

